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Re-combustion control means for alcohol engine.

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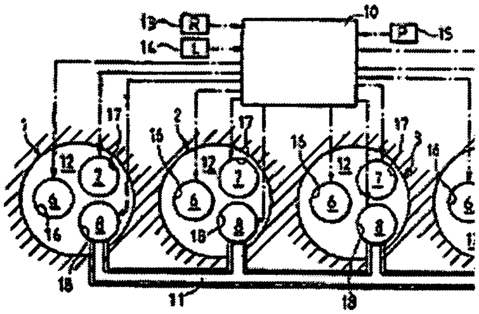
Abstract of **EP0426320**

This re-combustion control means for an alcohol engine comprises intake (6) and exhaust valves (7) designed to be opened or closed by virtue of magnetic force that are disposed, respectively, in intake and exhaust ports (16,17) of cylinders (1,2,3,4), control valves (8) designed to be opened or closed by virtue of magnetic force that are disposed, respectively, in combustion gas ports (18) communicating with each other via a combustion gas passageway (11), sensors (14) for detecting a state in which the engine is operated, and a controller (10), for controlling the supply of combustion gas from predetermined cylinders (1,4) to the other cylinders (2,3) via the combustion gas passageway (11) in response to a detection signal detected by the sensors (14). In response to a signal informing that the engine is under partial load, the exhaust valves (7) of the predetermined cylinders (1,4) are maintained in a closed state with the control valves (8) thereof being operated so as to be opened or closed, while the intake valves (6) of the other cylinders (2,3) are maintained in a closed state with the control valves thereof being operated so as to be opened or closed so that combustion gas produced in the predetermined cylinders (1,4) is taken into the other cylinders (2,3) and is reburned therein for complete combustion, the discharge of unburnt aldehyde or the like being thereby prevented.

FIG 2



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(54) **Re-combustion control means for alcohol engine.**

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DE-A- 2 827 630
DE-A- 3 007 927
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Description

The present invention relates to an alcohol engine having re-combustion control means and valves to be opened or closed by means of electromagnetic force.

More and more attention has been paid to alcohol engines since the environmental pollution due to exhaust gas discharged from engines became a social issue. Namely, as a fuel alcohol contains less carbon compared to gas oil and gasoline, and an alcohol engine using alcohol as a fuel is characterized in that the amount of carbon dioxide gas and carbides contanined in exhaust gas discharged therefrom is remarkably small compared to the amount of those contained in exhaust gas discharged from engines using gasoline, gas oil or the like as a fuel.

However, the latent heat for vaporization of alcohol is higher than that of gasoline; gasoline requires a vaporization latent heat of 0.7% of fuel heat value, while alcohol requires a vaporisation heat of 5% of fuel heat value. This means that alcohol fuel is difficult to vaporise, and moreover it is the characteristics of alcohol fuel that alcohol fuel injected from an injection nozzle into compressed air in a combustion chamber tends to lower the temperature of the compressed air and the wall surface of the combustion chamber due to vaporization, the ignition of fuel so injected being thereby adverse by effected.

It is well known that in a conventional exhaust gas re-circulating means for an engine unburnt fuel contained in exhaust gas discharged from cylinders of the engine is retaken into the cylinders for combustion, while a part of exhaust gas is caused to be mixed with suction air, the generation of NOx being thereby controlled.

However, in the alcohol engine using alcohol as a fuel, combustion under partial load is extremely different from that under high load, and due to this the alcohol engine has drawbacks in that combustion becomes unstable under partial load, while a speed at which air-fuel mixture is generated becomes low under high load. In particular, in a compression ignition type reciprocating engine, an ideal compression ratio for a normal direct injection type engine is generally accepted to range from 15 to 17. In this case, the compression end temperature is around 650 °C, and when the engine has just been started, or air is cold, poor ignition and combustion occur, resulting in misfire or incomplete combustion. This tends to facilitate the generation of unburnt gas, producing odor or irritating odor inherent therein when it is discharged outside.

In particular, in a diesel engine employing alcohol fuel, since the temperature of the wall surface of the combustion chamber thereof is not high, when the engine is at low speed under low load, due to the high latent heat for vaporization of alcohol, the wall surface takes from fuel heat required for vaporization, and this prevents the promotion of vaporization of fuel, thereby making it difficult to produce vaporized air-fuel mixture.

In addition, when the engine is under partial load, the air-fuel ratio is great, in other words, fuel is lean, and if alcohol fuel is burned in this state, intermediate products such as formaldehyde, acetaldehyde and so forth are produced.

As a result, fuel is not completely burned at a low temperature, and the phenomenon in which unburnt gas is produced is very likely to occur, producing the odor or irritating odor inherent in unburnt gas. Moreover, the amount of hydrocarbon contained in exhaust gas becomes large, and poor ignition of fuel, i.e. poor starting-up of the engine is expected. Therefore, in the engine employing alcohol fuel, the amount or aldehyde to be discharged from the engine under partial load becomes large, and this causes a problem of producing the irritating odor, odor or the like. Thus, there are many problems to be solved with combustion conditions in a partial load area at a low temperature.

In addition, in regard to the engine employing alcohol fuel, the official gazett of Japanese Patent Laid-Open No. 67959/1983, for instance, discloses an alcohol reformed engine using reformed gas obtained by reforming alcohol with a view to purifying exhaust gas.

Furthermore, the official gazette of Japanese Utility Model Laid-Open No. 105052/1984, for instance, discloses a reformed gas engine using as a fuel reformed gas that is reformed from liquid fuel by means of a reforming means disposed at a certain position along the length of the engine exhaust passageway.

A further engine in which gas re-combustion occurs is disclosed in US-A-4109625. The auxiliary chambers of the engine are in periodic communication thorugh a passageway opened and closed by a valve device which is operated so that combustion gas from a particular cylinder is exhausted in a minor part to another cylinder undergoing its intake stroke via the passageway, and in a major part through the conventional exhaust valve. This process occurs in each cylinder.

A further engine in which fuel-containing gas undergoes re-combustion is disclosed in US-A-3789807. The engine has low pressure cylinders and high pressure cylinders, gas being passed from a low pressure cylinder to a high pressure cylinder where primary combustion occurs and then back to a low pressure cylinder for re-combustion.

The present invention seeks to solve the above problems of alcohol engines by recognizing the fact that in an engine using alcohol as a fuel, although alcohol has a great latent heat for vaporization and is difficult to vaporize, unburnt intermediate products comprising aldehyde that are contained in exhaust gas discharged from the cylinders can be completely burned if they are sent back into the combustion chamber for re-combustion.

According to the present invention there is provided an alcohol engine with re-combustion control means, comprising a cylinder block provided with cylinders, a cylinder head secured to said cylinder block, pistons for reciprocation in said cylinders of said cylinder block, intake ports and exhaust ports formed in said cylinder head, for each cylinder, and intake valves and exhaust valves disposed in said intake ports and said exhaust ports respectively, and arranged to be selectively sequentially operable in a four stroke cycle of intake, compression, expansion and exhaust strokes; the re-combustion control means including: combustion gas ports formed in said cylinder head, for each cylinder, control valves disposed in said combustion gas ports, and a combustion gas passageway establishing communication between said combustion gas ports,

characterised in that the re-combustion control means further comprises:

valve driving means for operating said intake, exhaust and control valves so as to open or close the valves by means of electromagnetic force,

said re-combustion control means being operable such that alcohol fuel is burned with air introduced via said intake ports of selected cylinders, combustion gas from said selected cylinders is discharged only into said combustion gas passageway by opening said control valves during an exhaust stroke, said exhaust valves of the selected cylinders remaining closed when the combustion gas is being transferred via said combustion gas passageway during this exhaust stroke, combustion gas is supplied into the other cylinders from said combustion gas passageway on opening said control valves of said other cylinders on performing an intake stroke, said intake valves of said other cylinders remaining closed whilst the combustion gas is being transferred thereto, said combustion gas so supplied is re-burned in said other cylinders, and combustion gas resulting from this re-combustion is then discharged outside on opening said exhaust valves of said other cylinders during an exhaust stroke.

Such a re-combustion operation of the engine when the engine is under partial load ensures that unburnt intermediate products contained in combustion gas so sent can be more completely burned in the other cylinders, whereby the generation of aldehyde such as formaldehyde, acetaldehyde or the like is prevented, and the production of irritating odors, odors or the like is in turn prevented, thereby making it possible not only to purify exhaust gas to discharge it outside free from environmental health problem but also to improve the fuel economy of the engine through good combustion of fuel.

Preferably, the engine further comprises means for supplying alcohol fuel into said cylinders;

a load sensor for detecting the load state of the engine; and

a controller for performing controls such that in response to a detection signal from said load sensor indicating that the engine is under a partial load said exhaust valves of said selected cylinders are maintained in a closed state, with said control valves being operated so as to be opened or closed so that combustion gas is discharged into said combustion gas passageway via said combustion gas ports, while said intake valves of said other cylinders are maintained in a closed state with said control valves being operated so as to be opened or closed so that combustion gas in said combustion gas passageway is suppplied into said other cylinders via said combustion gas ports, combustion gas produced on re-burning being discharged via said exhaust ports of said other cylinders. Since combustion gas fed out into the combustion gas passageway has already been burned in the combustion chambers and hence is high in temperature, and since it has already become rich air-fuel mixture after a substantial amount of oxygen was consumed, when the rich air-fuel mixture is supplied into the combustion chambers of the other cylinders for re-combustion, unburnt aldehyde, hydrocarbon, carbon monoxide and so forth can be easily completely burned, whereby the inclusion of unburnt fuel and intermediate products in exhaust gas finally discharged from the engine is prevented, thereby making it possible to eliminate the generation of irritating odors, odors or the like in exhaust gas discharged outside.

Preferably, in response to a signal from the load sensor indicating that the engine is under high load the control valves are maintained in a closed state with the intake and exhaust valves thereof being normally operated so as to be opened or closed, in which case since combustion is actively performed when the engine is under high load, the temperature inside the combustion chambers is high, and the vaporization of alcohol fuel is promoted to thereby rapidly produce air-fuel mixture, which is then ignited to burn, the generation of unburnt aldehyde, hydrocarbon, carbon monoxide and so forth being thereby eliminated.

Preferably, said engine has four cylinders, wherein said re-combustion control means are arranged to allow suction air into two selected cylinders of said four cylinders via said intake ports and to discharge combustion gas into said combustion gas passageway via said combustion gas ports, and to allow combustion gas from said combustion gas passageway into said other two cylinders via said combustion gas ports, re-combustion gas being discharged outside via said exhaust ports. Not only is the output of the engine improved even when the engine is under partial load but also alcohol fuel is completely burned, thereby making it possible not only to execute good combustion by completely burning air-fuel mixture of alcohol fuel and suction air by re-burning combustion gas that has already been burned so that the generation of intermediate products such as aldehyde or the like, unburned gas, odors, irritating odors, hydrocarbon and so forth is prevented but also to improve the fuel economy of the engine.

Referring to the accompanying drawings, one embodiment of a re-combustion control means for an alcohol engine according to the present invention will be described by way of example only.

Fig. 1 is a cross-sectional view of an embodiment of a re-combustion control means for an alcohol engine according to the present invention,

Fig. 2 is an explanatory view explaining the control of the opening and/or closing operation of intake and exhaust valves and control valves of the re-combustion control means for an alcohol engine shown in Fig. 1, and

Fig. 3 is a process flow chart showing an example of the operation of the re-combustion control means for an alcohol engine shown in Fig. 1.

Fig. 1 is a schematic explanatory view showing one embodiment of the re-combustion control means for an alcohol engine according to the present invention, ani Fig. 2 is a schematic plan view explaining the re-combustion control means for an alcohol engine shown in Fig. 1. In this embodiment, a four-cylinder alcohol engine is taken as an example for the sake of clear understanding of an explanation of the recombustion control means for an alcohol engine to be made as below.

This alcohol engine comprises cylinders 19, constituted by four cylinders 1, 2, 3, 4, that are formed in a cylinder block, a cylinder head 12 secured to the cylinder block, and pistons 5 each designed to reciprocate in the respective cylinders 19. Intake ports 16 and exhaust ports 17 for the respective cylinders 1, 2, 3, 4 are formed in the cylinder head 12, and on top of these intake and exhaust ports 16, 17, combustion gas ports 18 as a third port for the respective cylinders 1, 2, 3, 4 are also formed in the cylinder head 12. Intake valves 6 are disposed, respectively, in the intake ports 16 formed in the cylinder head 12, and exhaust valves 7 are disposed, respectively, in the exhaust ports 17 formed in the cylinder head 12. Control valves 8 are also disposed, respectively, in the combustion gas ports 18. These combustion gas ports 18 are constructed such that they communicate with each other via a combustion gas passageway 11.

In addition, although not shown in the drawings, the intake ports 16 are connected to intake pipes so that suction air is introduced therethrough into the cylinders 19, i.e. cylinders 1, 2, 3, 4, and the exhaust ports 17 are connected to exhaust pipes so that exhaust gas produced in the cylinders 19 is discharged therefrom. Moreover, this alcohol engine has a fuel supply means for supplying alcohol fuel into the engine, i.e. the cylinders 19. This fuel supply means comprises a fuel injection pump and fuel injection nozzles for injecting alcohol fuel fed out of the fuel injection pump into the cylinders 19 or into the intake pipes.

This alcohol engine constructed as described above is designed to sequentially operate in four-cycle; intake, compression, expansion and exhaust strokes. In this alcohol engine, for instance, when the engine is under partial load, a high output of the engine is not needed, in which case suction air is taken into two cylinders out of the four for normal combustion, while the remaining two cylinders are operated so as only to take thereinto combustion gas resulting from the combustion of fuel in the two cylinders and perform expansion work by re-burning the combustion gas so taken into for complete combustion, clean exhaust gas resulting from the complete combustion being thereafter discharged outside. Namely, the intake valves 6 of the cylinders 1 and 4 are maintained in a closed state so that no suction air is taken thereinto from the outside with the control valves 8 thereof being operated so as to be opened or closed so that combustion gas produced in the cylinders 2 and 3 is taken into the cylinders 1 and 4 for the complete burning of the same. In contrast, the exhaust valves 7 of the cylinders 2 and 3 are maintained in a closed state so that combustion gas produced therein is not allowed to be discharged outside but is fed into the cylinders 1 and 4 by operating the control valves 8 so as to be opened or closed. To be concrete, as shown in Fig. 1, with the control valve 8 being opened, the cylinder 1 is in an initial stage of its intake stroke, while with the control valve 8 being opened, the cylinder 2 is in an initial stage of its exhaust stroke. At this time, with the control valve 8 being closed, the cylinder 3 is in an initial stage of its compression stroke, while with the control valve 8 being closed, the cylinder 4 is in an initial stage of its expansion stroke.

These intake, exhaust and control valves 6, 7, 8 are constructed so as to be opened or closed by virtue of electromagnetic force generated by valve driving means 9. These valve driving means 9 are designed to open or close the valves in response to commands sent from a controller 10. Receiving detection signals from revolution, load and position sensors 13, 14, 15, this controller 10 is designed not only to drive the valve driving means 9 for opening or closing the intake, exhaust and control valves 6, 7, 8 but also to control, for instance, the injection timing and injection volume of the fuel injection pump as a fuel supply means, as well as the operation of a glow lamp. Thus, the controller 10 controls the relevant means such that their operating conditions are optimized to a state in which the engine is currently being operated.

Taking the control valve 8 as an example, one embodiment of the valve driving means 9 that can be installed in the re-combustion control means for an alcohol engine will next be briefly described.

The control valve 8 is constructed such that it is opened or closed by energizing the valve driving means 9, and that it is maintained in a closed state when the valve driving means 9 is not energized. The valve face of the control valve 8 is brought into abutment with a valve seat provided on the combustion gas port 18 when the control valve 8 is caused to ascend, while the valve face is separated from the valve seat when the control valve 8 is caused to descend, the opening or closing of the combustion gas port 18 being thereby executed. Therefore, the volume of combustion gas to be taken into or discharged from the cylinders 19 is thus controlled by the opening or closing operation of the combustion gas port 18 or the area of the combustion gas port to be opened or closed.

A movable element formed from a magnetic material such as soft-iron or the like is secured to the top end portion of a valve stem of the control valve 8, and a movable-element coil is provided on this movable element. In addition, a stationary element formed from a magnetic material such as soft-iron or the like is placed above the movable element in such a manner as to correspond thereto, and a stationary-element coil is provided on this stationary element. In this construction, when operating the control valve 8 so as to open or close the same in response to a command from the controller 10, the energization of the movable-element and stationary-element coils may be executed or stopped in accordance with a command from the controller 10, whereby the stationary element draws the movable element thereto or causes the same to separate therefrom, the control valve 8 being thereby vertically moved.

Although not shown in the drawings, a valve spring is interposed between a valve spring seat formed on the top surface of the cylinder head 12 and the movable element. Therefore, the control valve 8 is normally biassed by the action of the spring force of the valve spring in such a direction as to close the combustion gas port 18, i.e., it is maintained in a closed state.

By constructing the control valve 8 as described above, the stationary element is allowed to separate from or draw to the movable element against the biassing force of the valve spring when the energization of the movable and stationary elements with current controlled by the controller 10 is executed or stopped, whereby the control valve 8 is caused to descend or ascend with the valve surface of the control valve 8 being caused to open or close the combustion gas port 18. It is needless to say that the construction of the valve driving means 9 is not limited to one described above.

Although a valve driving means for opening or closing the intake and exhaust valves 6, 7 is not shown in the drawings, a valve driving means 9 similar to one described above may be employed to open or close the intake and exhaust valves 6, 7. Therefore, the intake, exhaust and control valves 6, 7, 8 are constructed such that they are opened or closed independent of the crank angles.

The valve driving means 9 for controlling, respectively, the intake, exhaust and control valves 6, 7, 8 that can be installed in the re-combustion control means for an alcohol engine are designed to be controlled by signals sent from the controller 10 in accordance with detection signals supplied thereinto, respectively, from the revolution sensor 13 for detecting the number of revolutions of the cranks as the number of revolutions of the engine, the load sensor 14 for detecting the volume of fuel to be supplied from the fuel supply pump to the engine or the distance by which the accelerator pedal is stepped down as a load being put on the engine, and the position sensor 15 for detecting the crank angles as the position of stroke.

Referring to Figs. 1, 2 and 3, one example of the operation of the re-combustion control means for an alcohol engine according to the present invention will next be described. Fig. 3 is a process flow chart showing one example of the operation of the re-combustion control means for an alcohol engine according to the present invention.

When the engine is started, the fuel supply pump and the respective valve driving means 9 for the intake and exhaust valves 6, 7 are driven and controlled.

First, when the engine is started as a first step, the control valves 8 are operated by a command from the controller 10 so as to close the combustion gas ports 18. In this alcohol engine, the respective cylinders 1, 2, 3, 4 are designed to operate in four-cycle of intake, compression, expansion and exhaust strokes in accordance with commands sent by the controller 10. Alcohol fuel is supplied from the fuel injection pump constituting the fuel supply means to the fuel injection nozzles, and alcohol fuel so supplied is then injected from the fuel injection nozzles into the combustion chambers of the respective cylinders 1, 2, 3, 4 or into a suction air passageway communicating with the respective cylinders 1, 2, 3, 4. A detection signal sent from the load sensor 14 will be taken to explain detection signals supplied into the controller 10 so as to inform the same of a state in which the engine is being operated in this embodiment. It is needless to say that a signal sent from the revolution sensor 13 informing of the number of revolutions of the engine may be used as a detection signal.

In order to detect the engine load L_E by means of the load sensor 14, the volume of alcohol fuel to be supplied from the fuel injection pump to the fuel injection nozzles may be detected. A detection signal informing of the volume of alcohol fuel supplied to the fuel injection nozzles is supplied into the controller 10 as a signal informing of the engine load (Step 30). In synchronism with this, the crank angles of the respective cylinders 1, 2, 3, 4 are detected by means of the position sensor 15. These detection signals are then supplied to the controller 10, where which strokes the respective cylinders are currently performing is judged.

In the controller 10, the engine load L_E detected by the load sensor 14 is compared to a predetermined engine load L_{E1} so as to judge which is greater of the two loads (Step 31).

In a case where the engine load L_E is judged by the controller 10 as being greater than the predetermined engine load L_{E1}, the engine is under high load, and it is in a state in which combustion is being actively performed. Therefore, the temperature inside the combustion chambers is high, and the vaporization of alcohol fuel is being promoted, resulting in complete combustion of alcohol fuel. This means that unburnt aldehyde is not contained in exhaust gas, and hence there will be no problem of environmental pollution due to exhaust gas even if it is discharged outside. In this state, the controller 10 receives a signal informing that the engine is under high load, and sends a command to the valve driving means 9 that the control valves 8 be maintained in a closed state (Step 32), while the intake and exhaust valves 6, 7 are controlled by the associated valve driving means 9 so as to perform opening and closing operations in normal four-cycle sequence (Step 33). Therefore, the combustion chambers of the respective cylinders 1, 2, 3, 4 are put in a state in which combustion is actively being performed, and in this state, the vaporization of alcohol fuel is promoted, and good air-fuel mixture is produced. Therefore, the vaporization of atomized alcohol fuel is also promoted and combustion is effected in a smooth fashion, this preventing the generation of unburnt gas such as aldehyde or the like.

Following this, whether or not the engine continues to be driven is judged, and whether or not there are abnormal signals sent from the various types of sensors provided for the engine is judged in process steps. In a case where there is no abnormal signal found and where the engine continues to be run, the process flow goes back to Step 30, while in a case the engine is stopped or where there is/are an abnormal signal/signals found, the processing by this control means should be brought to an end.

In Step 31, in a case where the engine load L_E is judged by the controller 10 as being smaller than the predetermined engine load L_{E1}, the engine is under low load, and combustion being performed is not strong. In this state, the temperature inside the combustion chambers is low, and therefore the vaporization of alcohol fuel is not sufficient, and alcohol fuel is not able to be completely burned. Unburnt fuel of aldehyde is caused to remain in combustion gas produced in this state, and once such combustion gas is discharged outside as exhaust gas, this causes environmental pollution of odors or irritating odors. However, when the engine is under low load, a high output of the engine is not needed. In order to meet this requirement, in the alcohol engine of the present invention, the cylinders 2, 3 out of the four cylinders are driven such that suction air is taken thereinto from the outside, while the cylinders 1, 4 are controlled such that combustion gas produced in the cylinders 2, 3 is introduced thereinto so that combustion gas so taken into is re-burned therein for complete combustion. First, the controller 10 receives a signal informing that the engine is under low load, and sends a command to the valve driving means 9 that the control valves 8 of the respective cylinders 1, 2, 3, 4 be operated so as to be opened or closed, while it drives the valve driving means 9 such that the exhaust valves 7 of the cylinders 2, 3 are maintained in a closed state with the intake valves 6 of the cylinders 1, 4 being maintained in a closed state (Step 34).

In this state, in response to a command from the controller 10 the intake and control valves 6, 8 of the cylinders 2, 3 are operated so as to be opened or closed, while the control and exhaust valves 8, 7 of the cylinders 1, 4 are operated so as to be opened or closed. Therefore, the cylinders 2, 3 take thereinto suction air from the outside or air-fuel mixture of alcohol fuel via the intake pipe and the intake ports 16, and air-fuel mixture of alcohol fuel and suction air is burned with combustion gas so produced being discharged outside from the combustion gas port via the combustion gas passageway 11, while the cylinders 1, 4 take thereinto combustion gas from the combustion gas ports 18 via the combustion gas passageway 11 so that combustion gas so taken into is re-burned therein for complete combustion with exhaust gas resulting from the complete combustion being discharged outside from the exhaust ports 17 via the exhaust pipe (Step 35). In this construction, therefore, since combustion gas resulting from combustion of alcohol fuel in the combustion chambers of the cylinders 2, 3 is re-burned for complete combustion, exhaust gas discharged from the cylinders 1, 4 is clean and contains no unburnt aldehyde or the like, and hence the generation of odors or irritating odors is thus eliminated.

Following this, whether or not the engine continues to be driven is judged, and whether or not there are abnormal signals sent from the various types of sensors provided for the engine is judged in process steps. In a case where there is no abnormal signal found and where the engine continues to be run, the process flow goes back to Step 30, while in a case the engine is stopped or where there is/are an abnormal signal/signals found, the processing by this control means should be brought to an end.

Claims

1. An alcohol engine with re-combustion control means, comprising a cylinder block provided with cylinders (1,2,3,4), a cylinder head (12) secured to said cylinder block, pistons (5) for reciprocation in said cylinders (1,2,3,4) of said cylinder block, intake ports (16) and exhaust ports (17) formed in said cylinder head (12), for each cylinder, and intake valves (6) and exhaust valves (7) disposed in said intake ports (16) and said exhaust ports (17) respectively, and arranged to be selectively sequentially operable in a four stroke cycle of intake, compression, expansion and exhaust strokes; the re-combustion control means including: combustion gas ports (18) formed in said cylinder head (12), for each cylinder; control valves (8) disposed in said combustion gas ports (18), and a combustion gas passageway (11) establishing communication between said combustion gas ports (18);

   characterised in that the re-combustion control means further include:

   valve driving means (9) for operating said intake, exhaust and control valves (6,7,8) so as to open or close the valves by means of electromagnetic force;

   said re-combustion control means being operable such that alcohol fuel is burned with air introduced via said intake ports (16) of selected cylinders (2,3), combustion gas from said selected cylinders (2,3) is discharged only into said combustion gas passageway (11) by opening said control valves (8) during an exhaust stroke, said exhaust valves (7) of the selected cylinders (2,3) remaining closed when the combustion gas is being transferred via said combustion gas passageway during this exhaust stroke, combustion gas is supplied into the other cylinders (1,4) from said combustion gas passageway (11) on opening said control valves (8) of said other cylinders (1,4) on performing an intake stroke, said intake valves (6) of said other cylinders (1,4) remaining closed whilst the combustion gas is being transferred thereto, said combustion gas so supplied is re-burned in said other cylinders (1,4), and combustion gas resulting from this re-combustion is then discharged outside on opening said exhaust valves (7) of said other cylinders (1,4) during an exhaust stroke.

2. An alcohol engine having re-combustion control means as set forth in claim 1, wherein said engine has four cylinders (1,2,3,4), wherein said re-combustion control means are arranged to allow suction air into two selected cylinders (2,3) of said four cylinders (1,2,3,4) via said intake ports (16) and to discharge combustion gas into said combustion gas passageway (11) via said combustion gas ports (18), and to allow combustion gas from said combustion gas passageway (11) into said other two cylinders (1,4) via said combustion gas ports (18), re-combustion gas being discharged outside via said exhaust ports (17).

3. An alcohol engine having re-combustion control means as set forth in claim 1 or 2, wherein said valve driving means (9) are arranged to operate said intake and exhaust valves (6,7) and said control valves (8) so that said valves (6,7,8) are opened on electromagnetically energising said valve driving means and to be closed by a spring bias on deenergisation.

4. An alcohol engine having re-combustion control means as set forth in claim 1, 2 or 3, further comprising means for supplying alcohol fuel into said cylinders (1,2,3,4);

   a load sensor (14) for detecting the load state of the engine; and

   a controller (10) for performing controls such that in response to a detection signal from said load sensor (14) indicating that the engine is under a partial load said exhaust valves (7) of said selected cylinders (2,3) are maintained in a closed state, with said control valves (8) being operated so as to be opened or closed so that combustion gas is discharged into said combustion gas passageway (11) via said combustion gas ports (18), while said intake valves (6) of said other cylinders (1,4) are maintained in a closed state with said control valves (8) being operated so as to be opened or closed so that combustion gas in said combustion gas passageway (11) is suppplied into said other cylinders (1,4) via said combustion gas ports (11), combustion gas produced on re-burning being discharged via said exhaust ports (17) of said other cylinders (1,4).

5. An alcohol engine having re-combustion control means as set forth in claim 4, wherein said controller (10) is arranged to operate said valves such that in response to a detection signal from said load sensor (14) indicating that the engine is under a high load said control valves (8) are maintained in a closed state, with said exhaust and intake valves (7,6) being normally operated so that suction air is introduced into each of said cylinders (1,2,3,4) only via said intake ports (16), and with combustion gas being discharged only via said exhaust ports (17).

6. An alcohol engine having re-combustion control means as set forth in claim 4 or 5, wherein said load sensor (14) is arranged to detect the engine load by detecting the amount of alcohol fuel that is supplied to the engine.

Patentansprüche

1. Alkoholmotor mit Nachverbrennungs-Steuereinrichtung, welcher aufweist: einen mit Zylindern (1, 2, 3, 4) versehenen Zylinderblock, einen am Zylinderblock befestigten Zylinderkopf (12), in den Zylindern (1, 2, 3, 4) des Zylinderblocks hin und her gehende Kolben (5), im Zylinderkopf (12) ausgebildete Einlaßöffnungen (16) und Auslaßöffnungen (17) für jeden Zylinder, und in den Einlaßöffnungen (16) bzw. Auslaßöffnungen (17) angeordnete Einlaßventile (6) und Auslaßventile (7), die in einem aus Ansaug-, Kompressions-, Expansions- und Auslaßhub bestehenden Viertaktzyklus wahlweise nacheinander betätigbar sind; wobei die Nachverbrennungs-Steuereinrichtung umfaßt: im Zylinderkopf (12) ausgebildete Verbrennungsgasöffnungen (18) für jeden Zylinder; in den Verbrennungsgasöffnungen (18) angeordnete Steuerventile (8), sowie einen Verbrennungsgaskanal (11), der eine Verbindung zwischen den Verbrennungsgasöffnungen (18) herstellt; dadurch gekennzeichnet, daß die Nachverbrennungs-Steuereinrichtung ferner umfaßt: Ventilantriebseinrichtungen (9) zum Betätigen der Einlaß-, Auslaß- und Steuerventile (6, 7, 8) derart, daß die Ventile durch elektromagnetische Kraft geöffnet oder geschlossen werden; wobei die Nachverbrennungs-Steuereinrichtung derart betätigbar ist, daß alkoholischer Kraftstoff mit über die Einlaßöffnungen (16) ausgewählter Zylinder (2, 3) eingeleiteter Luft verbrannt wird, Verbrennungsgas aus den ausgewählten Zylindern (2, 3) ausschließlich in den Verbrennungsgaskanal (11) ausgestoßen wird, indem die Steuerventile (8) eines Auslaßhubes geöffnet werden, die Auslaßventile (7) der ausgewählten Zylinder (2, 3) geschlossen bleiben, wenn das Verbrennungsgas während dieses Auslaßhubes über den Verbrennungsgaskanal geleitet wird, Verbrennungsgas in die anderen Zylinder (1, 4) aus dem Verbrennungsgaskanal (11) beim Öffnen der Steuerventile der anderen Zylinder (1, 4) während der Durchführung eines Ansaughubes eingeleitet wird, die Ansaugventile (6) der anderen Zylinder (1, 4) geschlossen bleiben, während das Verbrennungsgas in dieselben geleitet wird, das so eingeleitete Verbrennungsgas in den anderen Zylindern (1, 4) nachverbrannt wird, und das aus dieser Nachverbrennung stammende Verbrennungsgas sodann nach außen abgelassen wird, indem die Auslaßventile (7) der anderen Zylinder (1, 4) während eines Auslaßhubes geöffnet werden.

2. Alkoholmotor mit Nachverbrennungs-Steuereinrichtung nach Anspruch 1, bei dem der Motor vier Zylinder (1, 2, 3, 4) aufweist, die Nachverbrennungs-Steuereinrichtung so ausgebildet ist, daß sie die Ansaugung von Luft in zwei ausgewählte Zylinder (2, 3) der vier Zylinder (1, 2, 3, 4) über die Einlaßöffnungen (16) und das Entlassen von Verbrennungsgas in den Verbrennungsgaskanal (11) über die Verbrennungsgasöffnungen (18) sowie die Strömung von Verbrennungsgas aus dem Verbrennungsgaskanal (11) in die zwei anderen Zylinder (1, 4) über die Verbrennungsgasöffnungen (18) ermöglicht, wobei das Nachverbrennungsgas über die Auslaßöffnungen (17) nach außen abgelassen wird.

3. Alkoholmotor mit Nachverbrennungs-Steuereinrichtung nach Anspruch 1 oder 2, bei dem die Ventilantriebseinrichtungen (9) so ausgebildet sind, daß sie die Einlaß- und Auslaßventile (6, 7) und die Steuerventile (8) derart betätigen, daß die Ventile (6, 7, 8) durch elektromagneti-

sches Erregen der Ventilantriebseinrichtungen geöffnet und durch Federbelastung bei Entregung geschlossen werden.

4. Alkoholmotor mit Nachverbrennungs-Steuereinrichtung nach Anspruch 1, 2 oder 3, welcher aufweist: eine Einrichtung zur Zuführung von alkoholischem Kraftstoff in die Zylinder (1, 2, 3, 4);
einen Lastsensor (14) zum Erfassen des Belastungszustandes des Motors; und
eine Steuereinrichtung (10) zur Durchführung von Steuerungen derart, daß in Abhängigkeit von einem Erfassungssignal aus dem Lastsensor (14), das anzeigt, daß der Motor unter Teilbelastung steht, die Auslaßventile (7) der ausgewählten Zylinder (2, 3) in einem geschlossenen Zustand gehalten werden, wobei die Steuerventile (8) so betätigt werden, daß sie derart geöffnet oder geschlossen werden, daß Verbrennungsgas in den Verbrennungsgaskanal (11) über die Verbrennungsgasöffnungen (18) abgeleitet wird, während die Einlaßventile (6) der anderen Zylinder (1, 4) in einem geschlossenen Zustand gehalten werden, wobei die Steuerventile (8) so betätigt werden, daß sie sich derart schließen oder öffnen, daß Verbrennungsgas im Verbrennungskanal (11) in die anderen Zylinder (1, 4) über die Verbrennungsgasöffnungen (11) eingeleitet wird, und wobei beim Nachverbrennen erzeugtes Verbrennungsgas über die Auslaßöffnungen (17) der anderen Zylinder (1, 4) abgelassen wird.

5. Alkoholmotor mit Nachverbrennungs-Steuereinrichtung nach Anspruch 4, bei dem die Steuereinrichtung (10) so ausgebildet ist, daß sie die Ventile derart betätigt, daß in Abhängigkeit von einem Erfassungssignal aus dem Lastsensor (14), das anzeigt, daß der Motor unter hoher Belastung steht, die Steuerventile (8) in einem geschlossenen Zustand gehalten werden, wobei die Auslaß- und Einlaßventile (7, 6) normalerweise derart betätigt werden, daß Ansaugluft in jeden der Zylinder (1, 2, 3, 4) nur über die Einlaßöffnungen (16) angesaugt wird, und wobei Verbrennungsgas ausschließlich über die Auslaßöffnungen (17) abgelassen wird.

6. Alkoholmotor mit Nachverbrennungs-Steuereinrichtung nach Anspruch 4 oder 5, bei dem der Lastsensor (14) so ausgebildet ist, daß er die Motorbelastung durch Erfassen der Menge des dem Motor zugeführten alkoholischen Kraftstoffs erfaßt.

Revendications

1. Moteur à alcool avec des moyens de commande de recombustion, comprenant un bloc de cylindres doté de cylindres (1, 2, 3, 4), une culasse (12) fixée audit bloc de cylindres, des pistons (5) pour aller et venir dans lesdits cylindres (1, 2, 3, 4) dudit bloc de cylindres, des conduits d'admission (16) et des conduits d'échappement (17) formés dans ladite culasse (12), pour chaque cylindre, et des soupapes d'admission (6) et des soupapes d'échappement (7) disposées dans lesdits conduits d'admission (16) et lesdits conduits d'échappement (17) respectivement, et adaptées à être actionnées sélectivement de manière séquentielle en un cycle à quatre temps d'admission, de compression, de détente et d'échappement; les moyens de commande de recombustion comprenant : des conduits de gaz de combustion (18) formés dans ladite culasse (12), pour chaque cylindre; des soupapes de commande (8) disposées dans lesdits conduits de gaz de combustion (18), et un passage de gaz de combustion (11) établissant une communication entre lesdits conduits de gaz de combustion (18);

caractérisé en ce que les moyens de commande de recombustion comprennent en outre :

des moyens de commande de soupapes (9) pour actionner lesdites soupapes d'admission, d'échappement et de commande (6, 7, 8) afin d'ouvrir ou de fermer les soupapes au moyen d'une force électromagnétique;

lesdits moyens de commande de recombustion pouvant être actionnés de manière que le combustible alcool soit brûlé avec l'air introduit via lesdits conduits d'admission (16) des cylindres sélectionnés (2, 3), le gaz de combustion desdits cylindres sélectionnés (2, 3) soit déchargé uniquement dans ledit passage de gaz de combustion (11) en ouvrant lesdites soupapes de commande (8) durant un temps d'échappement, lesdites soupapes d'échappement (7) des cylindres sélectionnés (2, 3) restant fermées lorsque le gaz de combustion est transféré via ledit passage de gaz de combustion durant ledit temps d'échappement, le gaz de combustion soit distribué dans les autres cylindres (1, 4) dudit passage de gaz de combustion (11) lors de l'ouverture desdites soupapes de commande (8) desdits autres cylindres (1, 4) lors d'un temps d'admission, lesdites soupapes d'admission (6) desdits autres cylindres (1, 4) restant fermées tandis que le gaz de combustion est transféré jusqu'à elles, ledit gaz de combustion ainsi distribué soit rebrûlé

dans lesdits autres cylindres (1, 4), et le gaz de combustion résultant de cette recombustion soit alors déchargé à l'extérieur lors de l'ouverture desdites soupapes d'échappement (7) desdits autres cylindres (1, 4) durant un temps d'échappement.

2. Moteur à alcool avec des moyens de commande de recombustion selon la revendication 1, dans lequel ledit moteur comporte quatre cylindres (1, 2, 3, 4), dans lequel lesdits moyens de commande de recombustion sont agencés de manière à autoriser l'air d'aspiration dans deux cylindres sélectionnés (2, 3) desdits quatre cylindres (1, 2, 3, 4) via lesdits conduits d'admission (16) et à décharger le gaz de combustion dans ledit passage de gaz de combustion (11) via lesdits conduits de gaz de combustion (18), et à autoriser le gaz de combustion dudit passage de gaz de combustion (11) dans lesdits deux autres cylindres (1, 4) via lesdits conduits de gaz de combustion (18), le gaz de recombustion étant déchargé à l'extérieur via lesdits conduits d'échappement (17).

3. Moteur à alcool avec des moyens de commande de recombustion selon la revendication 1 ou 2, dans lequel lesdits moyens de commande de soupapes (9) sont agencés pour actionner lesdites soupapes d'admission et d'échappement (6, 7) et lesdites soupapes de commande (8) de manière que lesdites soupapes (6, 7, 8) soient ouvertes lors de l'excitation électromagnétique desdits moyens de commande de soupapes et soient fermées par une sollicitation élastique lors de la désexcitation.

4. Moteur à alcool avec des moyens de commande de recombustion selon la revendication 1, 2 ou 3, comprenant en outre des moyens pour distribuer le combustible alcool dans lesdits cylindres (1, 2, 3, 4);

un capteur de charge (14) pour détecter l'état de charge du moteur; et

un contrôleur (10) pour effectuer des commandes de manière qu'en réponse à un signal de détection dudit capteur de charge (14) indiquant que le moteur est sous une charge partielle lesdites soupapes d'échappement (7) desdits cylindres sélectionnés (2, 3) soient maintenues dans un état fermé, avec lesdites soupapes de commande (8) étant actionnées afin d'être ouvertes ou fermées de manière que le gaz de combustion soit déchargé dans le passage de gaz de combustion (11) via lesdits conduits de gaz de combustion (18), tandis que lesdites soupapes d'admission (6) desdits autres cylindres (1, 4) sont maintenues dans un état fermé avec lesdites soupapes de commande (8) étant actionnées de manière à être ouvertes ou fermées afin que le gaz dans ledit passage de gaz de combustion (11) soit distribué dans lesdits autres cylindres (1, 4) via lesdits conduits de gaz de combustion (18), le gaz de combustion produit lors de la recombustion étant déchargé via lesdits conduits d'échappement (17) desdits autres cylindres (1, 4).

5. Moteur à alcool avec des moyens de commande de recombustion selon la revendication 4, dans lequel ledit contrôleur (10) est agencé pour actionner lesdites soupapes de manière qu'en réponse à un signal de détection provenant dudit capteur de charge (14) indiquant que le moteur est sous une charge élevée lesdites soupapes de commande (8) soient maintenues dans un état fermé, avec lesdites soupapes d'admission et d'échappement (7, 6) étant normalement actionnées de manière que l'air d'aspiration soit introduit dans chacun desdits cylindres (1, 2, 3, 4) uniquement via lesdits conduits d'admission (16), et avec le gaz de combustion étant déchargé uniquement via lesdits conduits d'échappement (17).

6. Moteur à alcool avec des moyens de commande de recombustion selon la revendication 4 ou 5, dans lequel ledit capteur de charge (14) est agencé pour détecter la charge du moteur en détectant la quantité de combustible alcool qui est distribuée au moteur.

FIG. 1

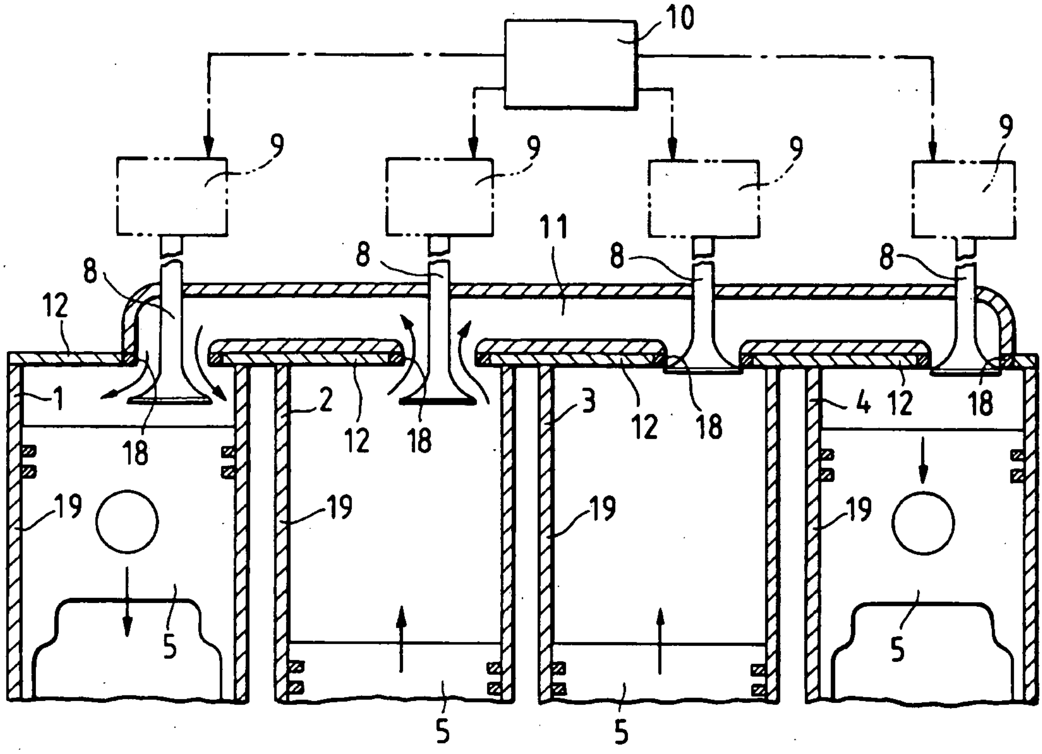


FIG. 2

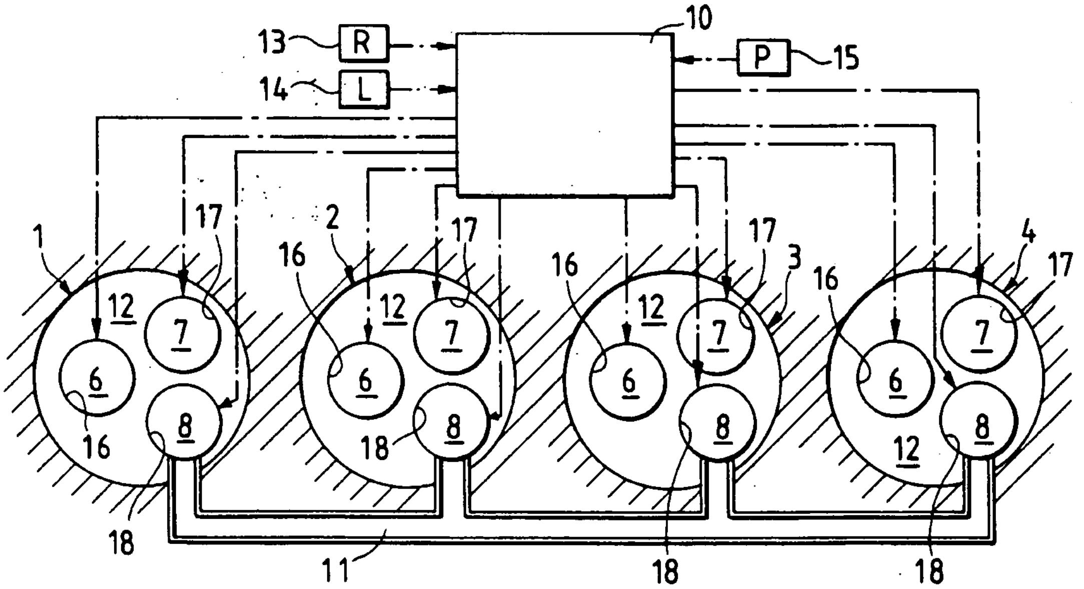
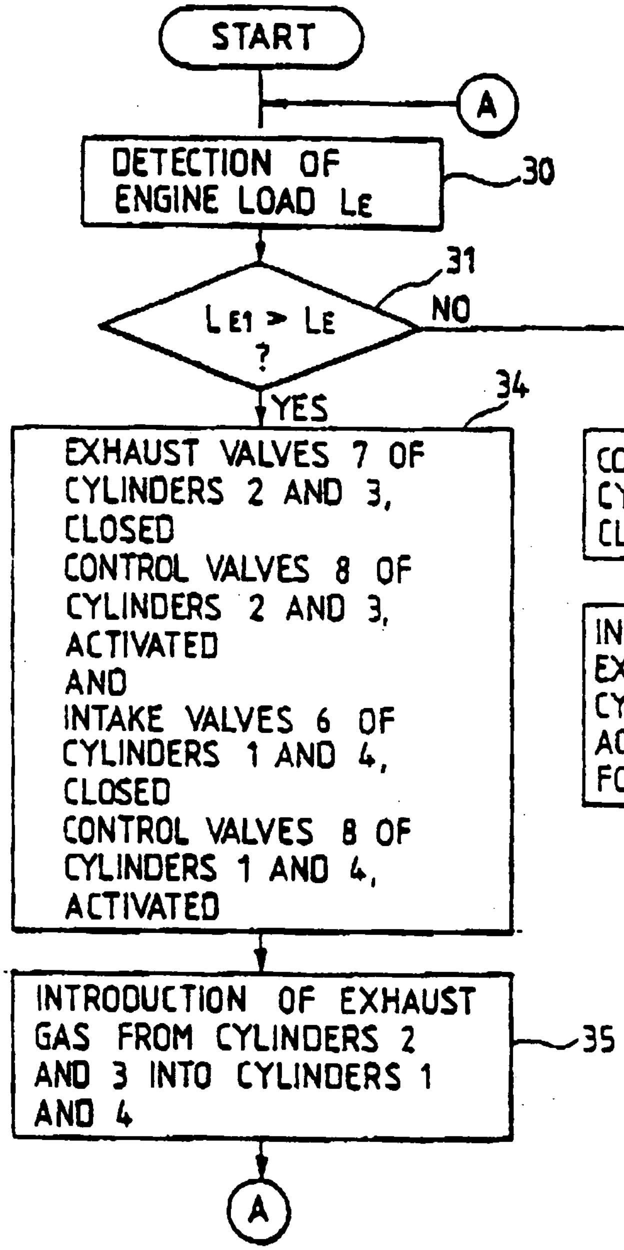

R
L
P

FIG. 3


START
A
DETECTION OF ENGINE LOAD L_E
30
31
$L_{E1} > L_E$?
NO
YES
34
EXHAUST VALVES 7 OF CYLINDERS 2 AND 3, CLOSED
CONTROL VALVES 8 OF CYLINDERS 2 AND 3, ACTIVATED
AND
INTAKE VALVES 6 OF CYLINDERS 1 AND 4, CLOSED
CONTROL VALVES 8 OF CYLINDERS 1 AND 4, ACTIVATED
32
CONTROL VALVES 8 OF CYLINDERS 1 TO 4, CLOSED
INTAKE VALVES 6 AND EXHAUST VALVES 7 OF CYLINDERS 1 TO 4 ACTIVATED IN ORDINARY FOUR-CYCLE OPERATION
33
A
INTRODUCTION OF EXHAUST GAS FROM CYLINDERS 2 AND 3 INTO CYLINDERS 1 AND 4
35
A